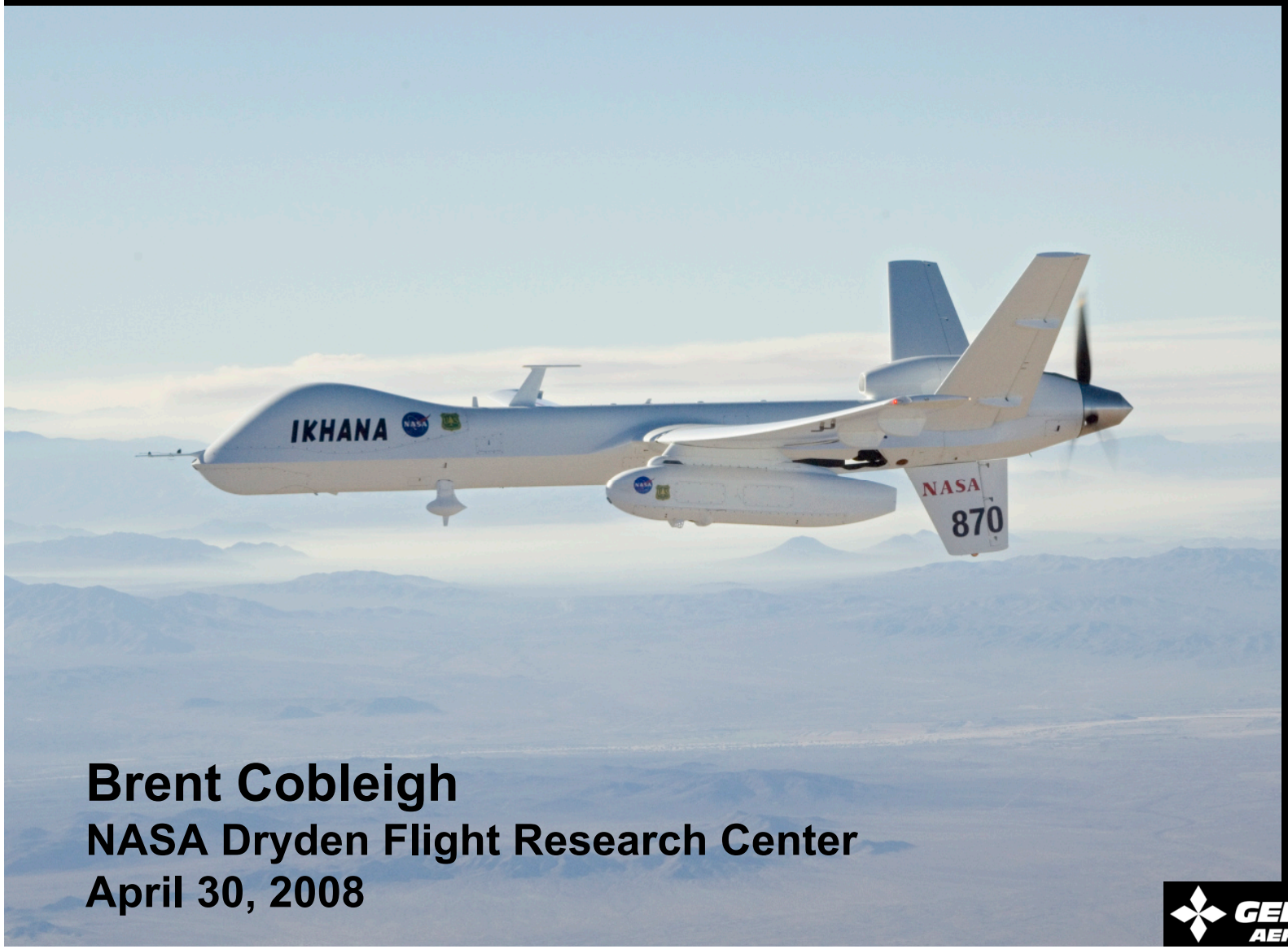
2007 Ikhana Western States & Southern California Emergency UAS Fire Missions



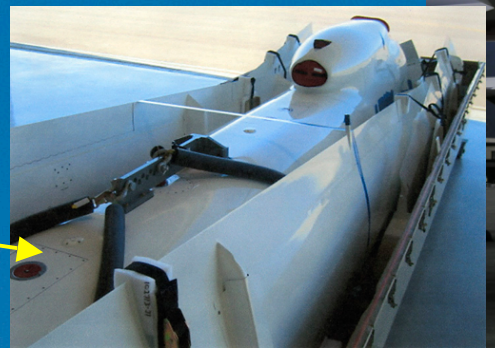
Brent Cobleigh
NASA Dryden Flight Research Center
April 30, 2008

GENERAL ATOMICS
AERONAUTICAL SYSTEMS

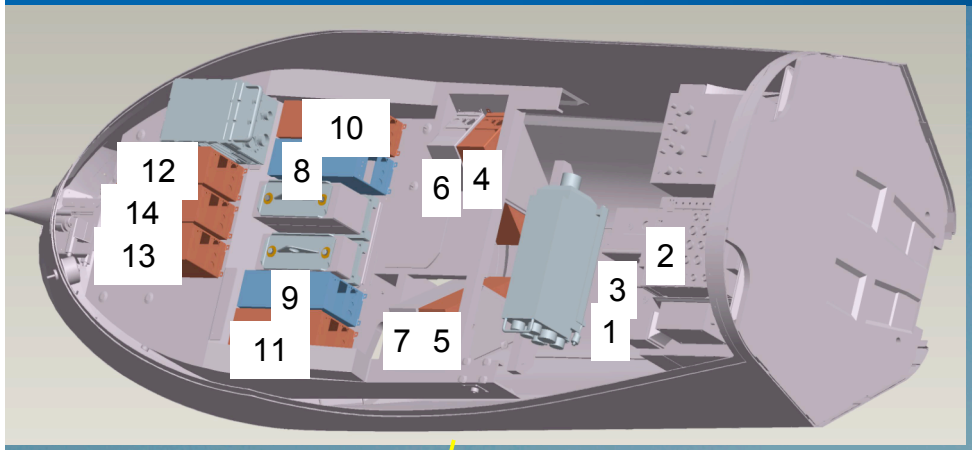
Aircraft Overview

- Endurance > 24 hours
  - Allows measurements of day/night atmospheric variations
  - Access to remote areas
- Altitude >40,000 ft
- Payload Capability
  - More than 450 lbs today
  - Potential for 2000+ lbs

- Reliability
  - Triple redundant flight control systems
  - Dual redundant power & networks
  - Highly reliable engine
  - More than 400,000 flight hours
  - Proven “lost link” capability
- Deployability

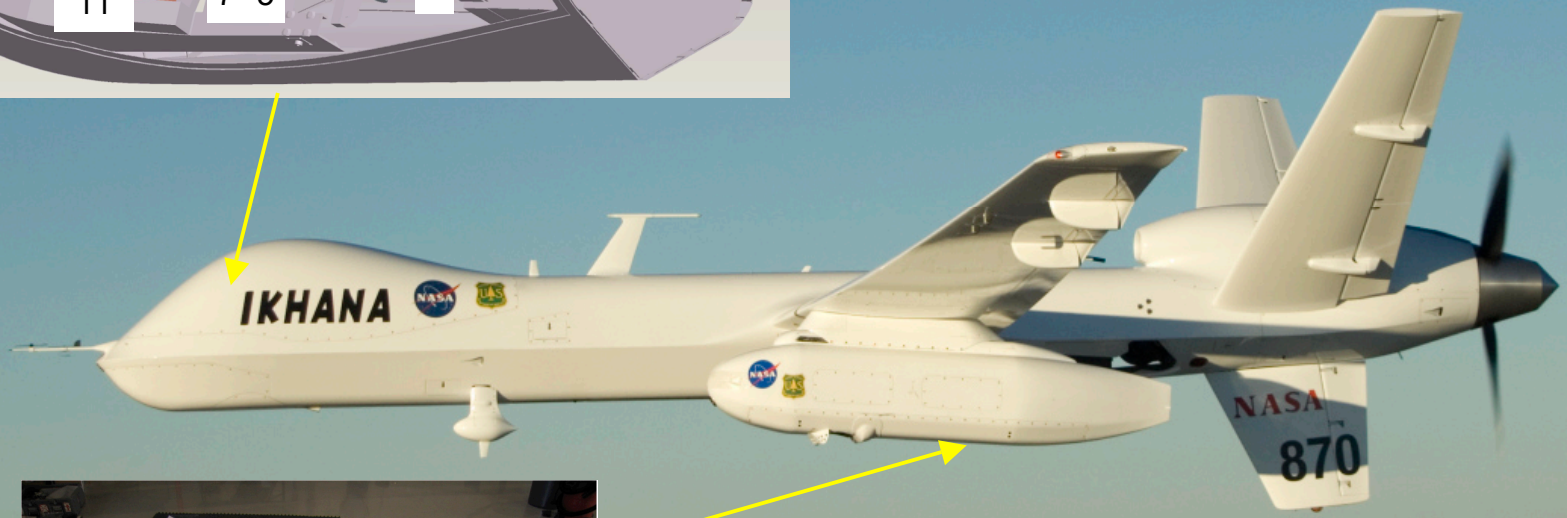


Western States Fire Mission Modifications



Back-up battery power increased to 3 hours

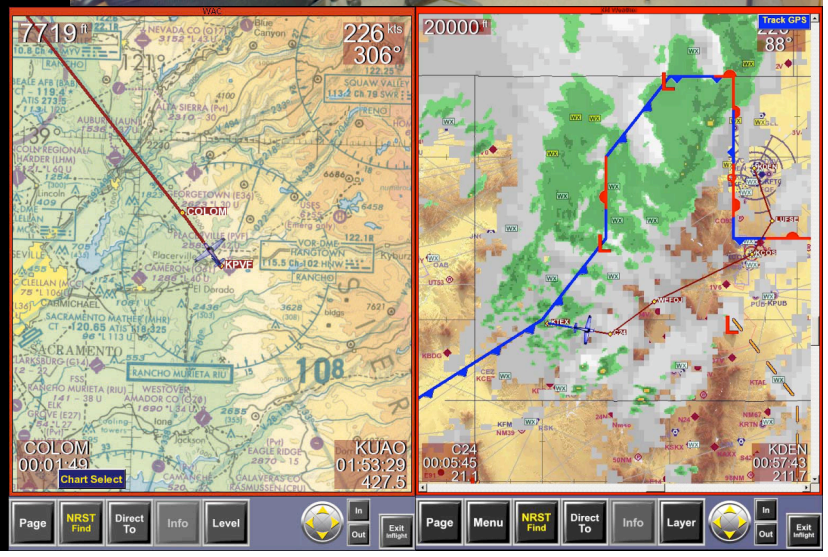
Wiring connections from pod to power distribution, GPS antenna, and SatCom system



Infrared Wildfire Scanner

Ground Systems

- Mobile Ground Control Station
  - Dual pilot control station
  - Electronic navigation charts
  - Weather
  - 6 Engineering/Science workstations
  - Range safety workstation
  - Intercom system throughout
  - Overhead mission displays
  - Telephones
  - Remote video from aircraft start-up/shut-down site
  - Downlink video and data recording
- Mobile 2.4m Ku SatCom Antenna
  - Dual redundant receiver/transmitters

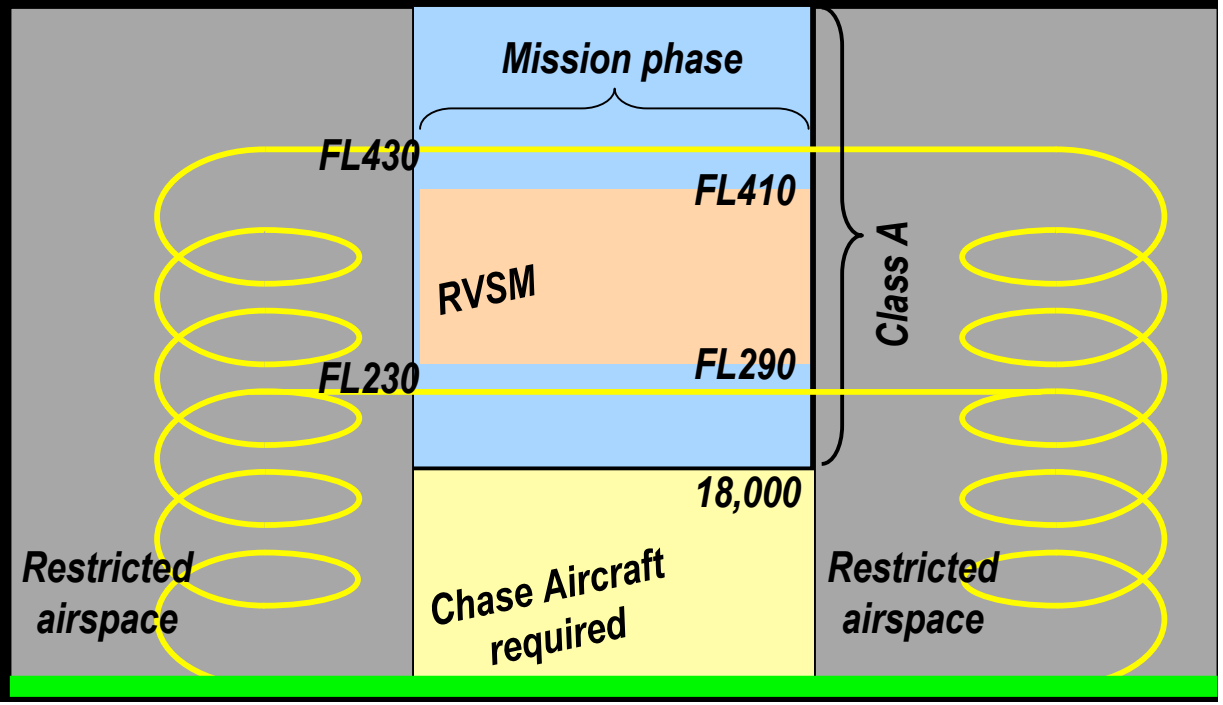


2007 Western States Fire Mission Objectives

- Demonstrate capabilities of UAS to image widespread fires throughout Western US.
- Demonstrate long-endurance mission capabilities (20-hours+).
- Image multiple fires (greater than 4 fires) per mission
- Demonstrate new UAV-compatible, autonomous sensor for improved thermal characterization of fires.
- Provide automated, on-board, terrain and geo-rectified sensor imagery over OTH satcom links to national fire personnel and Incident commanders within 10 minutes.
- Demonstrate Collaborative Decision Environment

Operations Concept

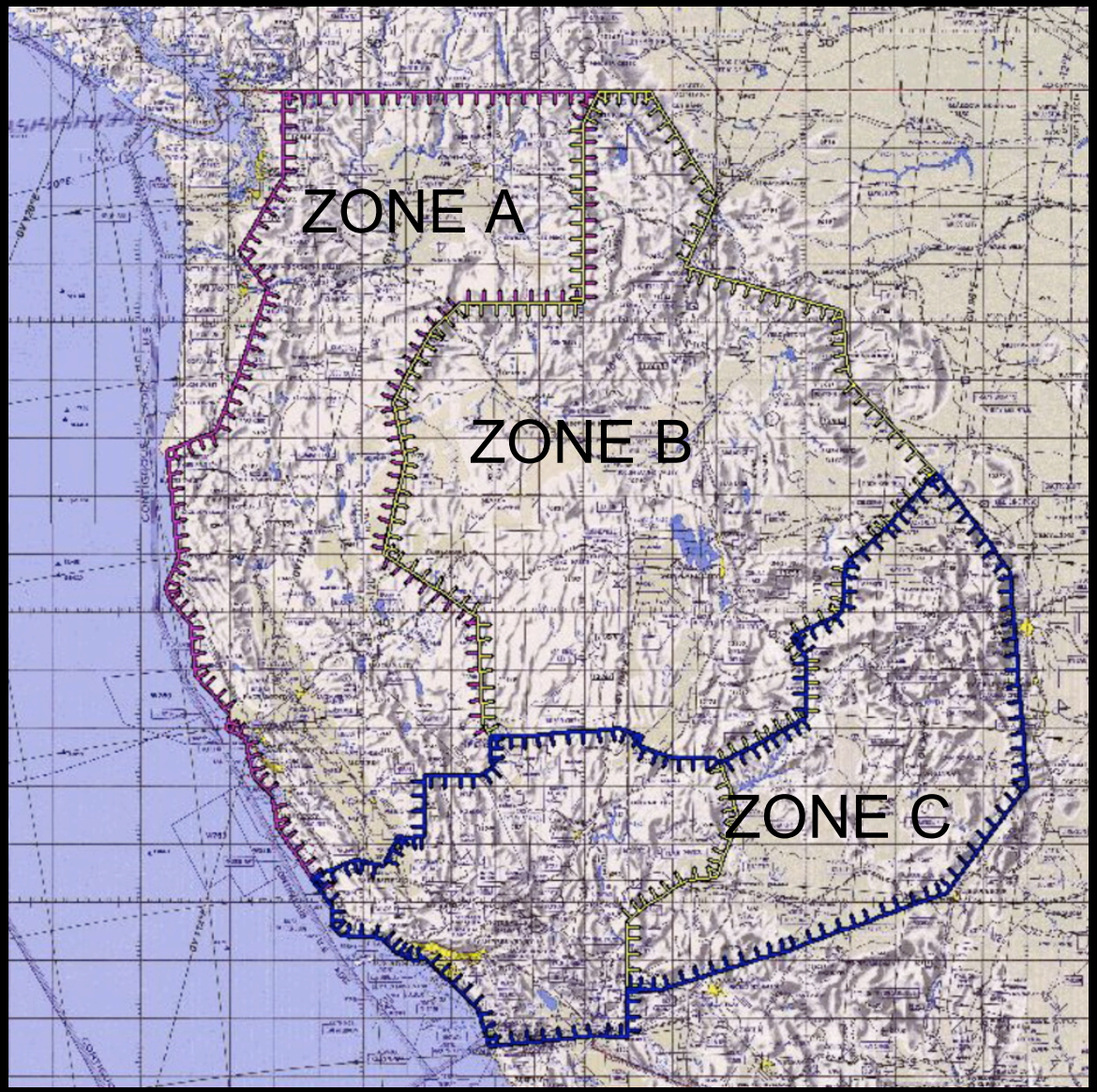
- Chase aircraft required below 18k in the U.S. National Airspace (NAS)
- Air traffic control (ATC) used for collision avoidance above 18,000 ft
- NASA Dryden uses restricted airspace to climb to cruise altitude before exiting into the NAS
- Since Ikhana not qualified for Reduced Vertical Separation Minima (RVSM), operations are limited to 18,000 ft to FL 290 or above FL 410
- Transponder and radio communication required



Certificate of Authorization (COA) Boundary Request

3 Operational Zones

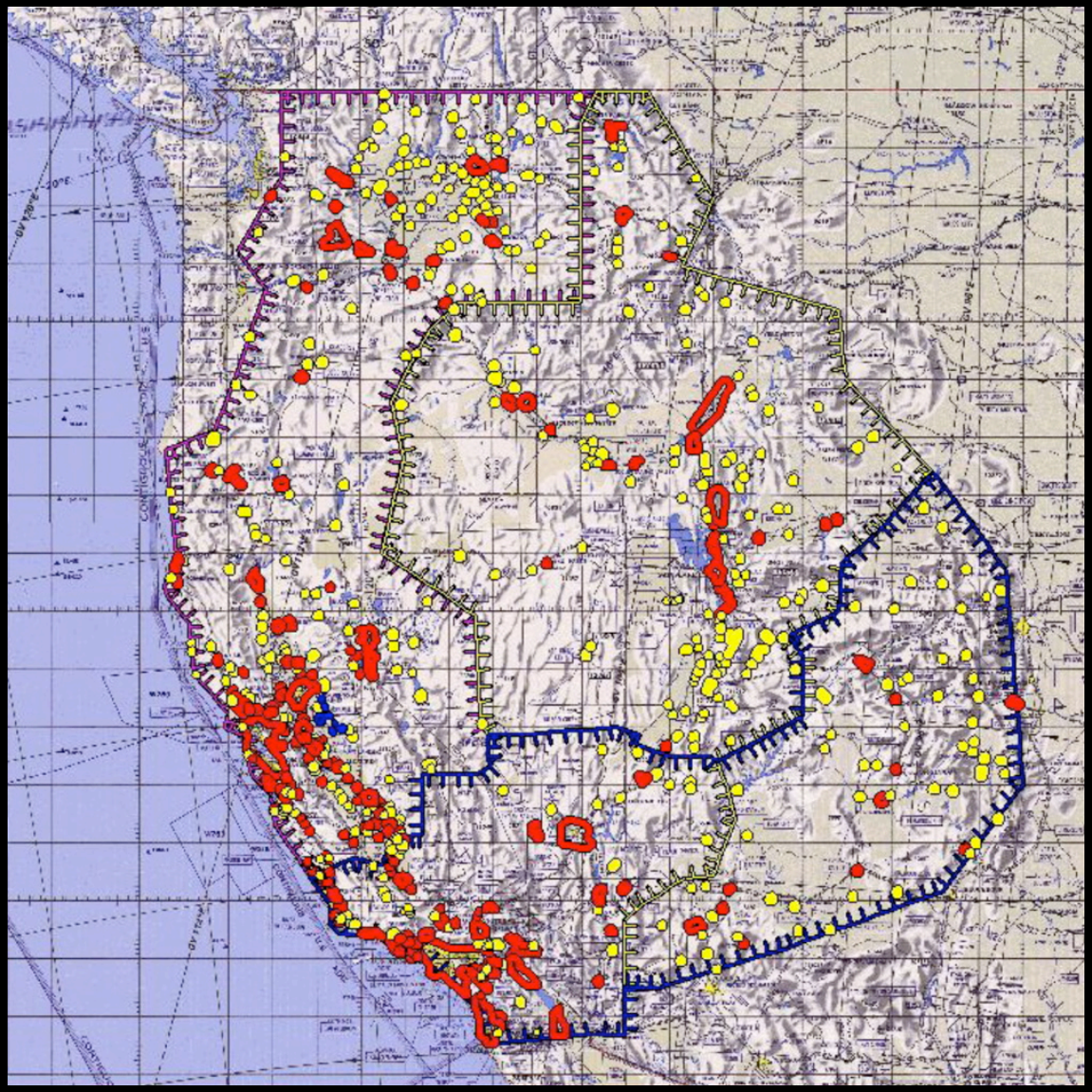
Each zone includes no more than 3 ARTCC areas



Range Safety Protection Zones

KEEP-OUT ZONES

- NOMINAL AIRCRAFT
- UNHEALTHY AIRCRAFT



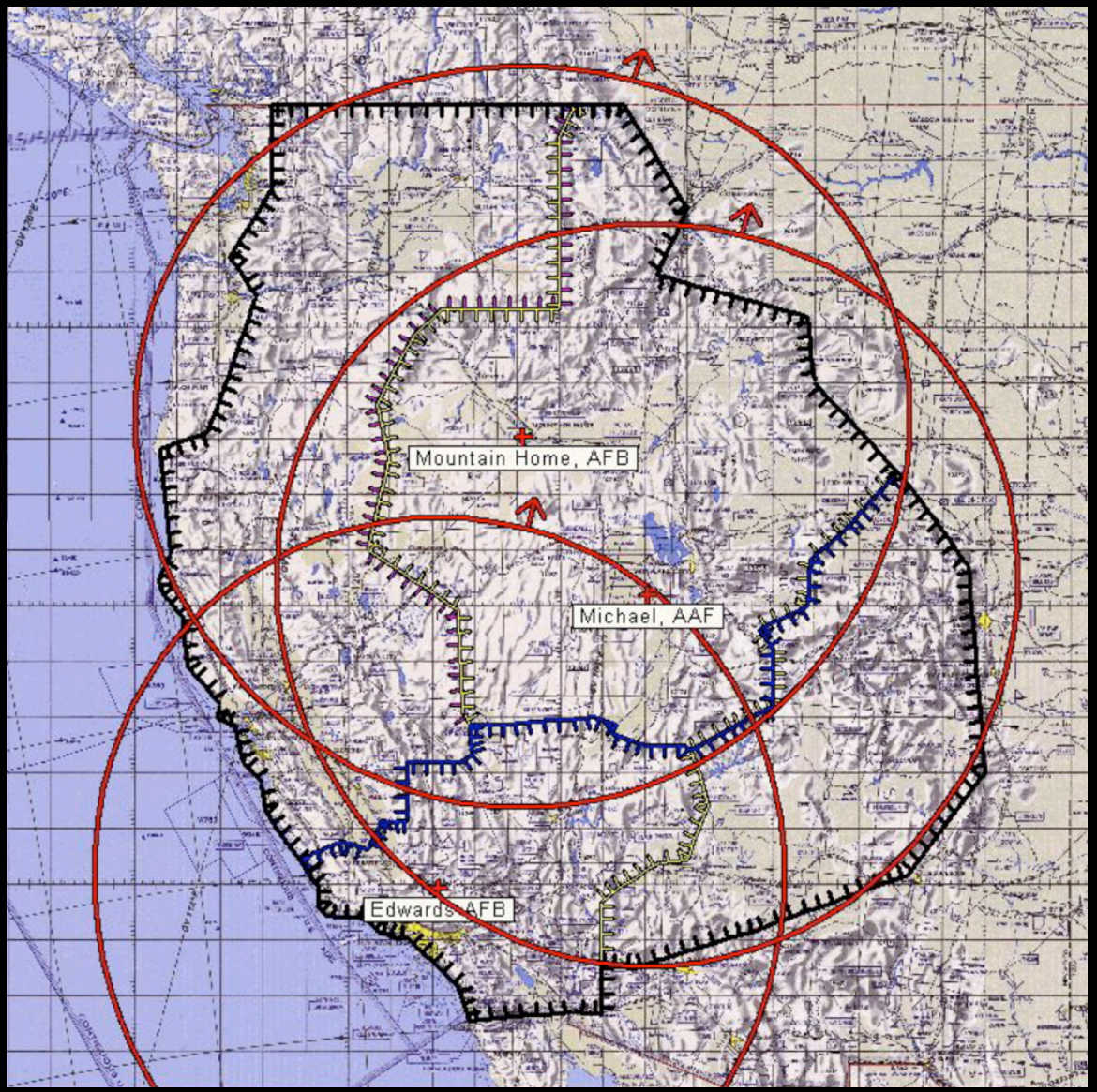
Primary Emergency Landing Sites

Radius =400 nmi

Minimum Range on Battery Power

Aircraft has single generator

Landing agreements negotiated with each site



Secondary Emergency Landing Sites

Radius=50 nmi

Minimum glide distance from 23,000 ft

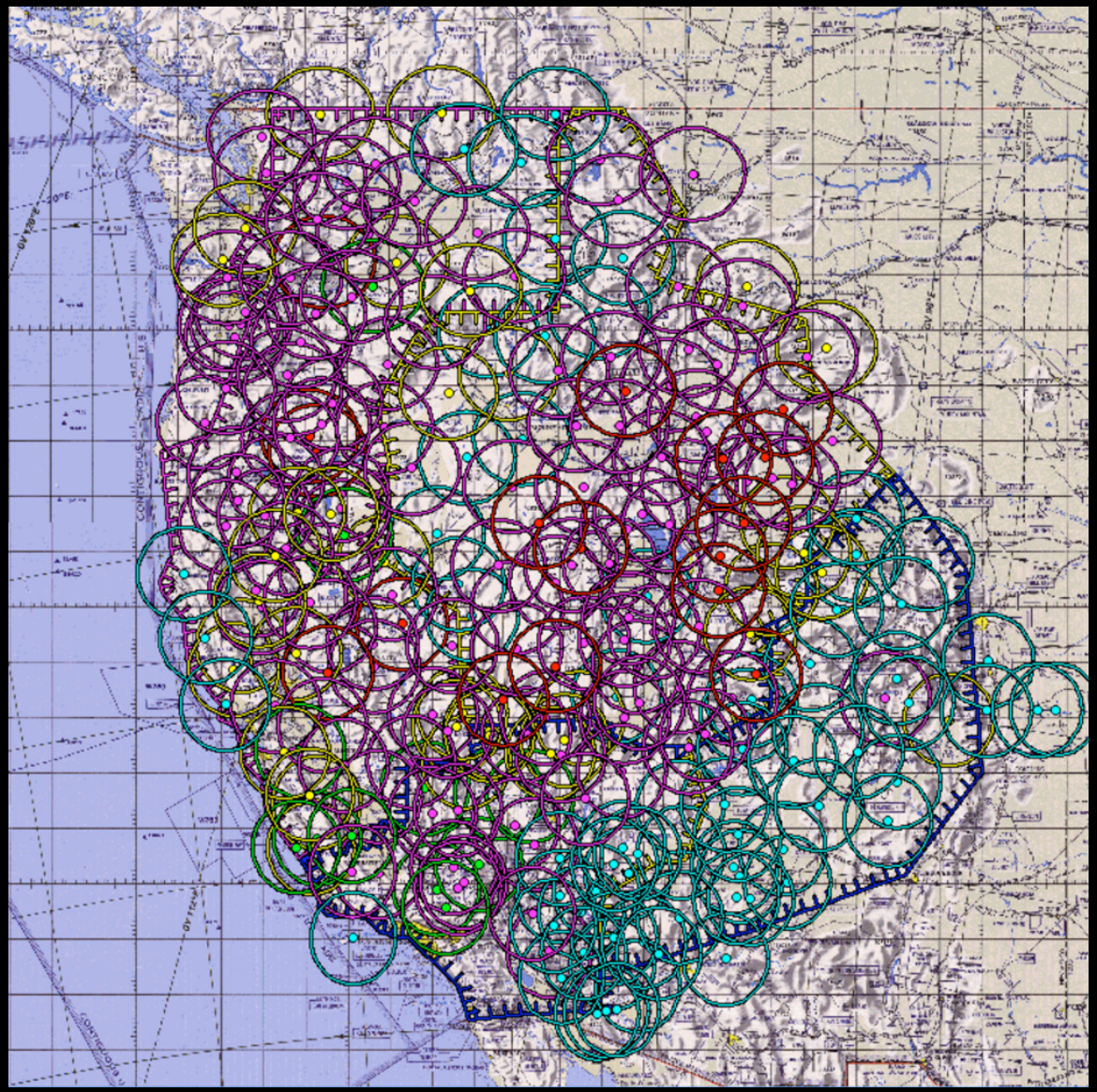
Over 280 sites identified

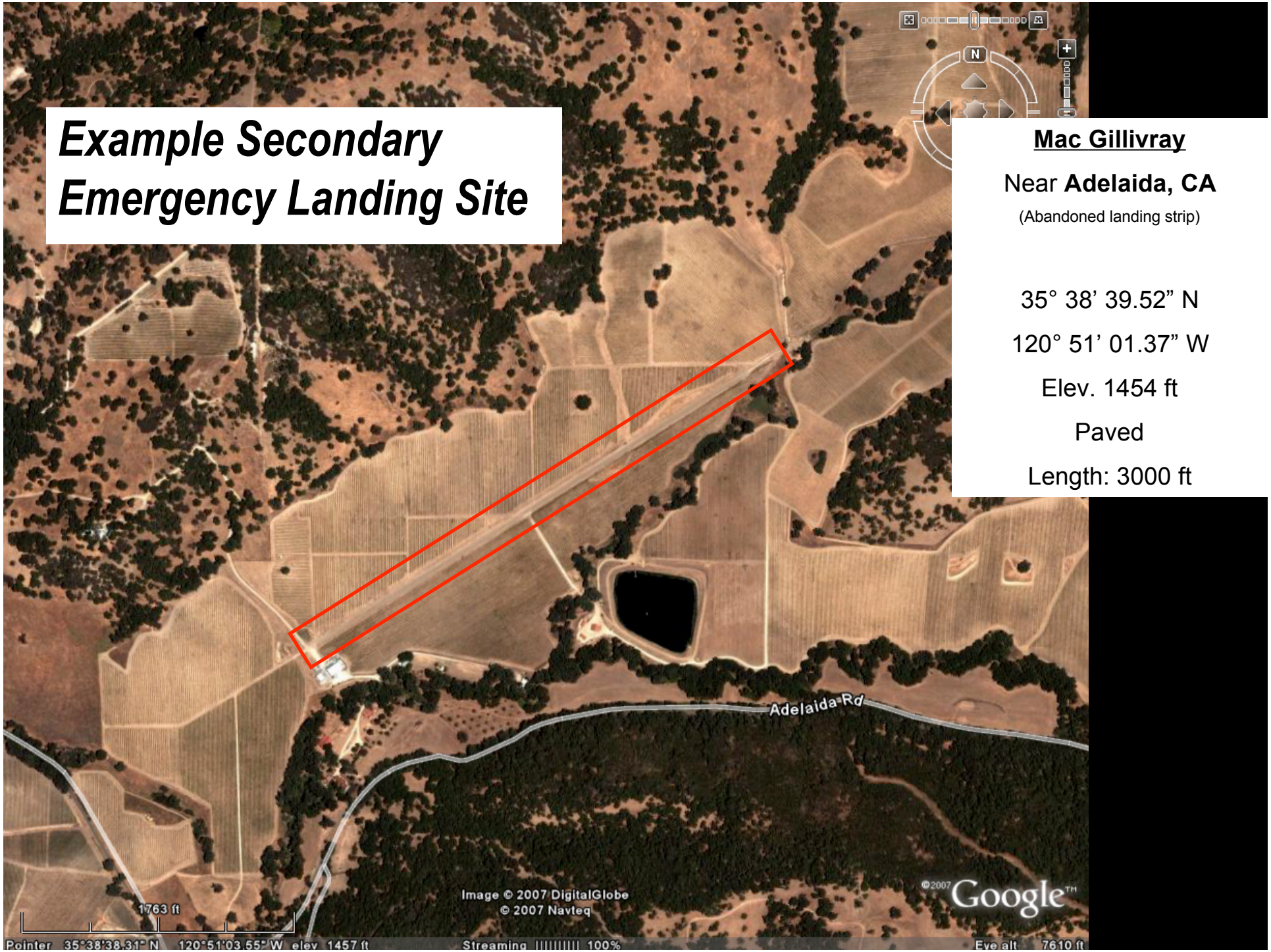
Categorized Green, Yellow, Purple, Red by pilots

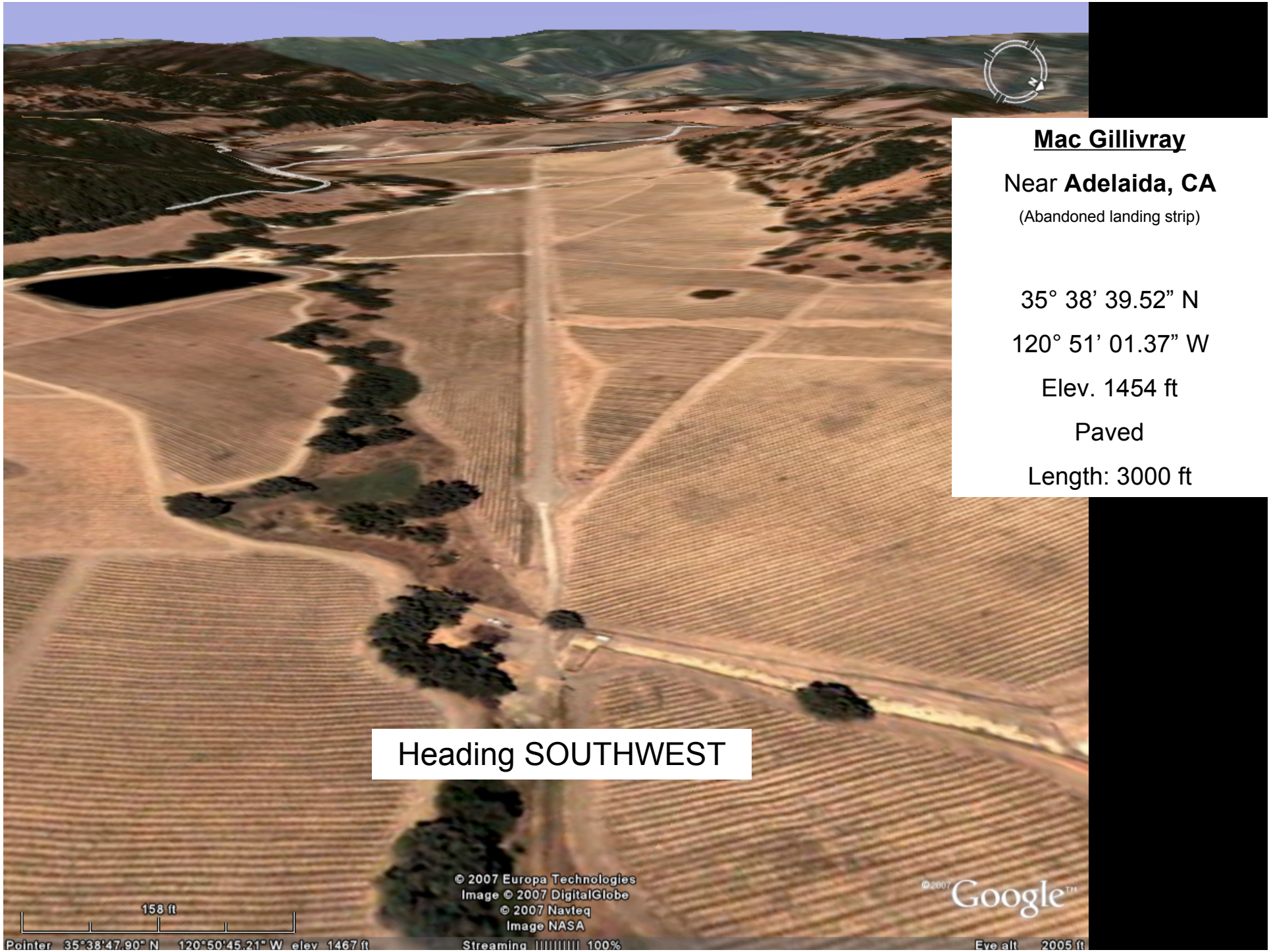
Selected in unpopulated areas. Abandoned runways, dry lakebeds, flat ground, ditch areas

Primary purpose is to protect public

Actively managed during each mission




Example Secondary
Emergency Landing Site
Mac Gillivray
Near Adelaida, CA
(Abandoned landing strip)
35° 38’ 39.52” N
120° 51’ 01.37” W
Elev. 1454 ft
Paved
Length: 3000 ft
Adelaida Rd
1763 ft
Image © 2007 DigitalGlobe
© 2007 Navteq
©2007 Google
Pointer 35°38'38.31" N 120°51'03.55" W elev 1457 ft
Streaming 100%
Eye alt 7610 ft



Mac Gillivray

Near **Adelaida, CA**

(Abandoned landing strip)

35° 38’ 39.52” N

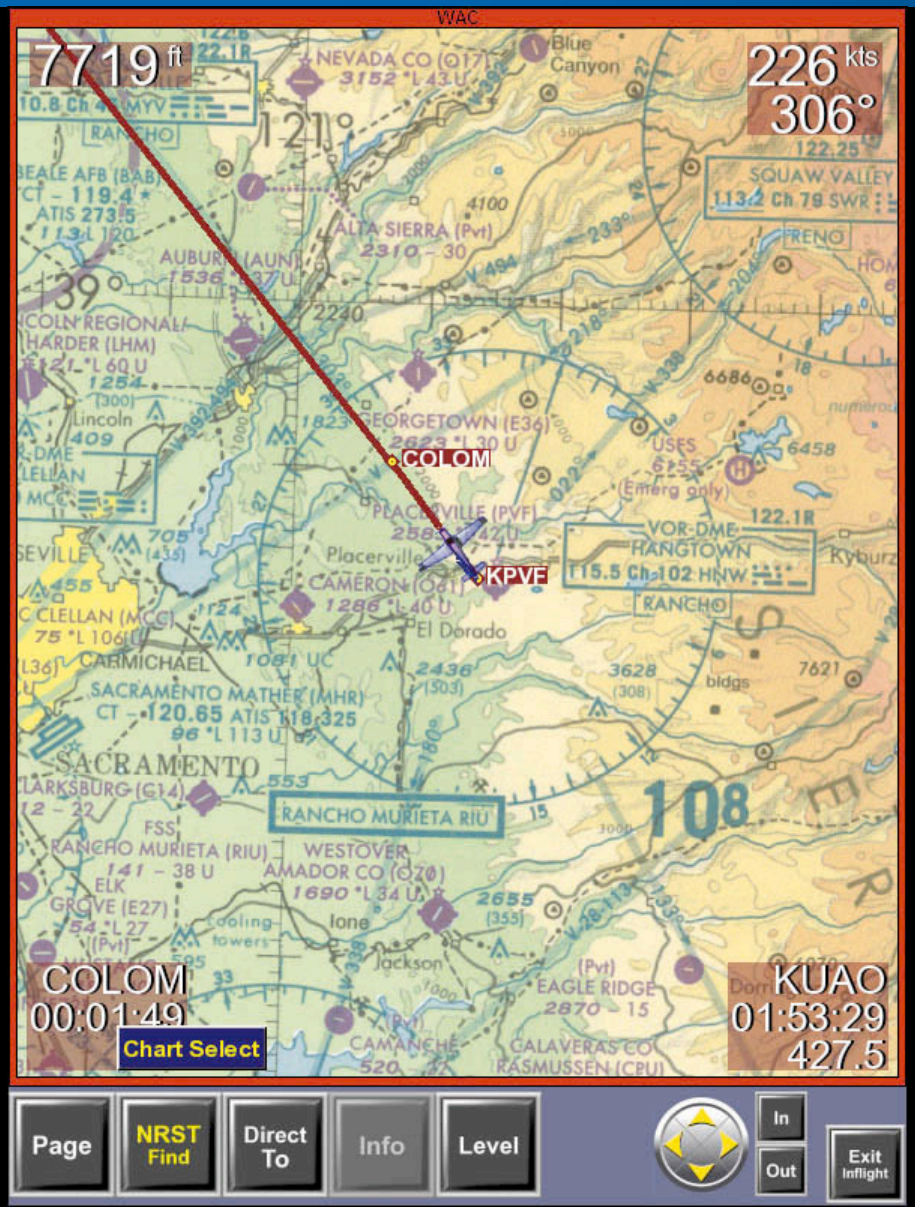
120° 51’ 01.37” W

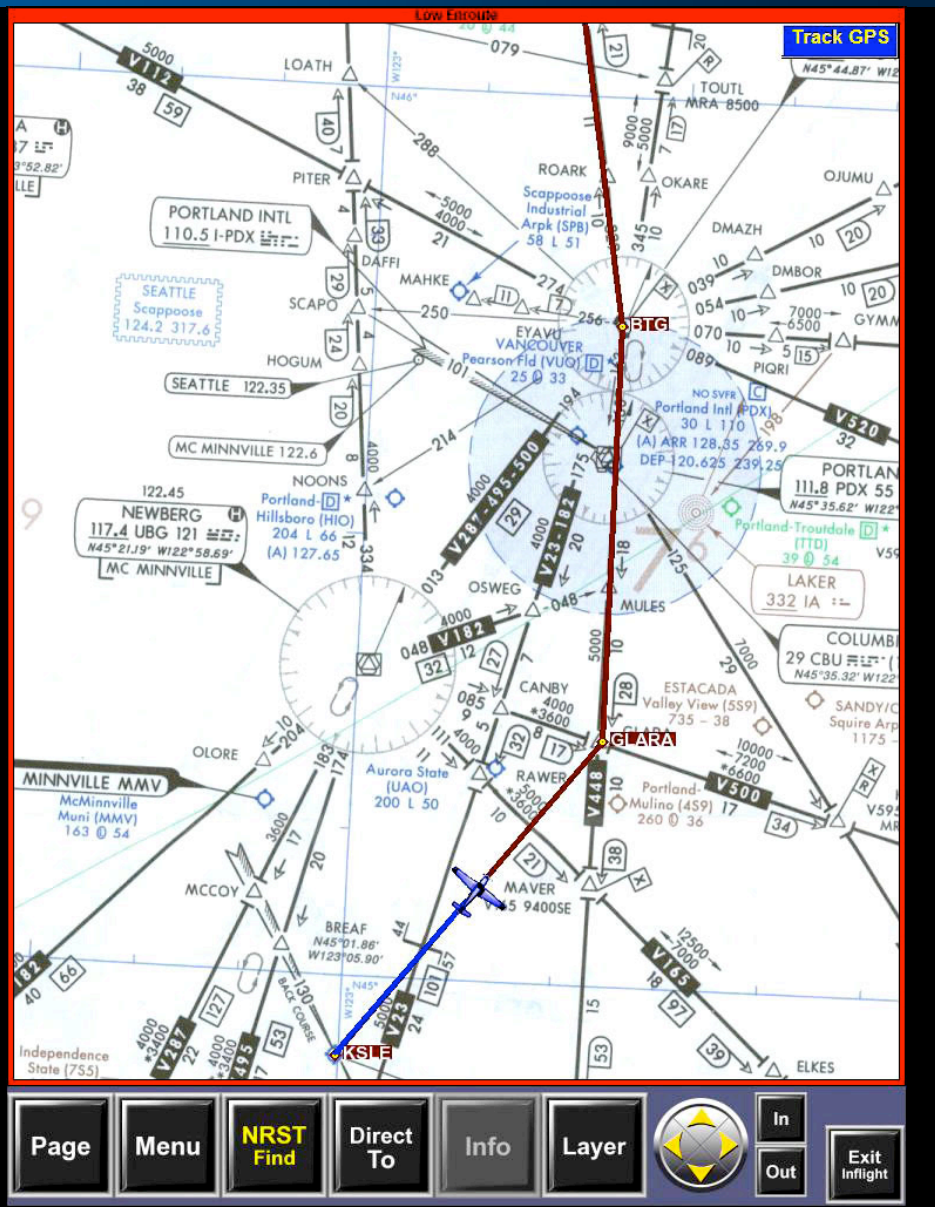
Elev. 1454 ft

Paved

Length: 3000 ft

Chart Case Professional





COA: Special Provisions

- 3 business day mission notification to FAA
- IFR Flight Plan submitted 24 hours in advance
- Mission Planning telecon with affected ATC Centers 24 hours prior to mission
- Point to point flight plan
- Remain within 75nm of ‘backbone’ route
- Stay 10 nm away from International borders (Canada, Mexico)

COA: Special Provisions

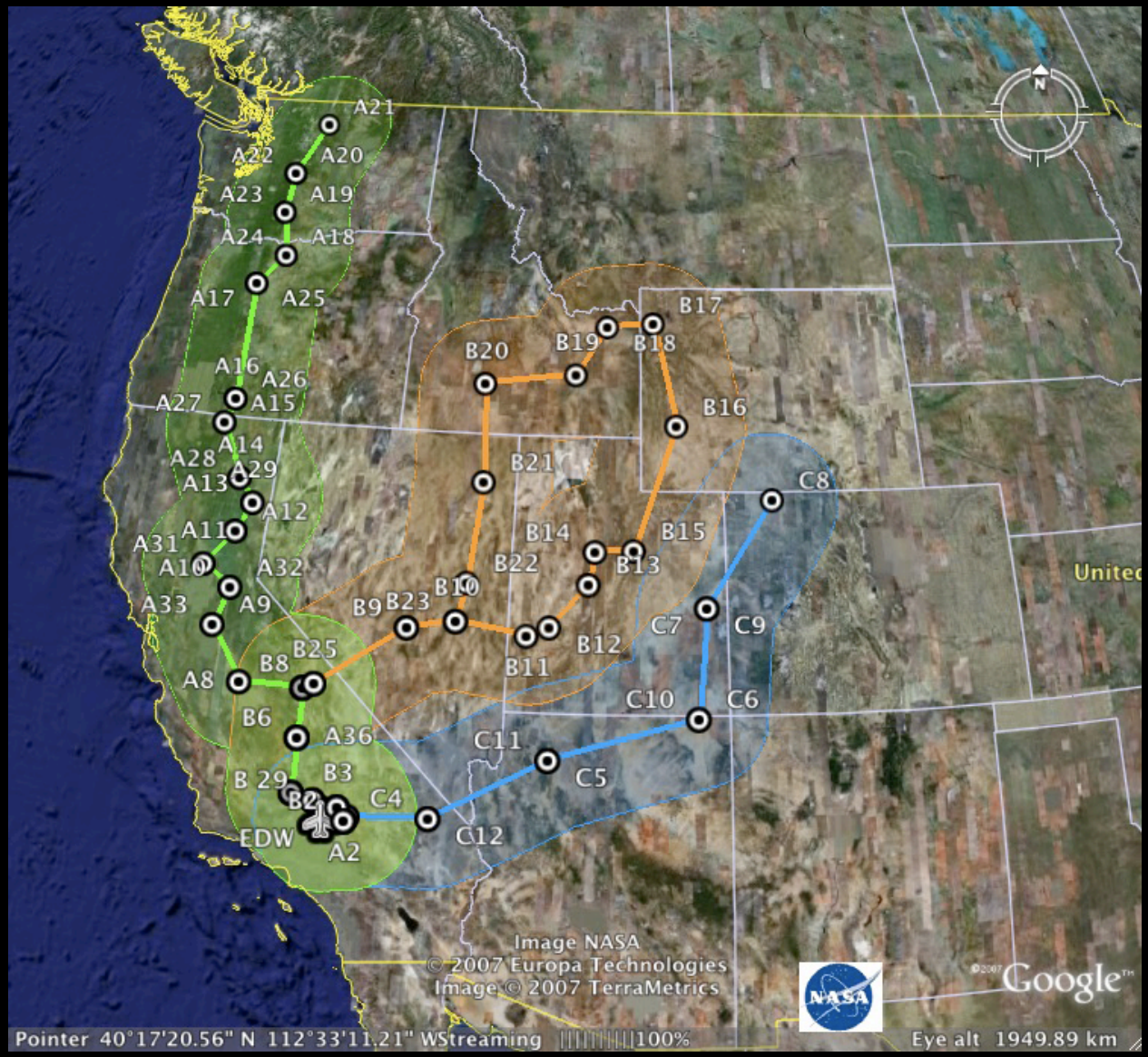
- Public Use aircraft
- NASA self-certifies for airworthiness

- No flight in to forecasted “moderate or severe” turbulence
- No flight in area where convective SIGMET has been issued
- No flight in area of known or forecast icing
- No flight in area of affected by GPS testing, solar storms or RAIM outages

COA: Special Provisions

- Lost link procedure
  - Maintain altitude
  - Continue on filed flight plan (the route) for 15 min
    - Does not mean “keep going straight ahead for 15 minutes”
    - If in a loiter area, stay in there for at least 15 minutes
  - Squawk 7600
  - Aircraft will turn right, if it has to retrace the flight plan
  - Aircraft will return to R-2508/R-2515 the way it came out (usually)

Approved COA Area



First 4 Fire Missions

1st Fire Mission 8/16/07
9.5 hours
1400 nmi

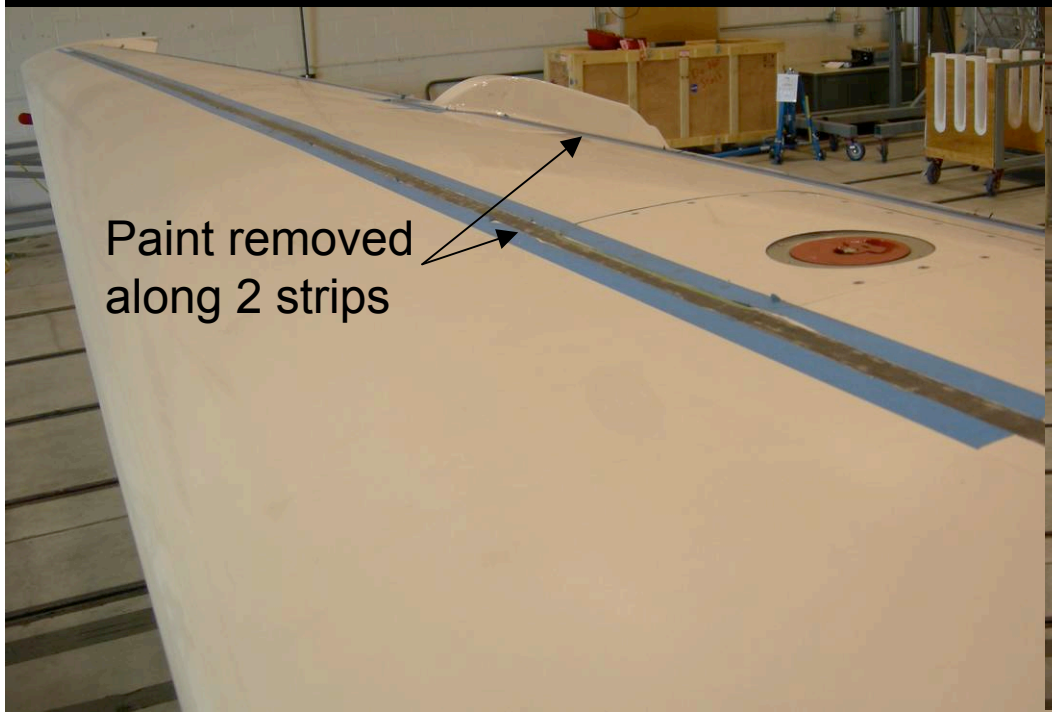
2nd Fire Mission 8/29/07
16.1 hours
2500 nmi

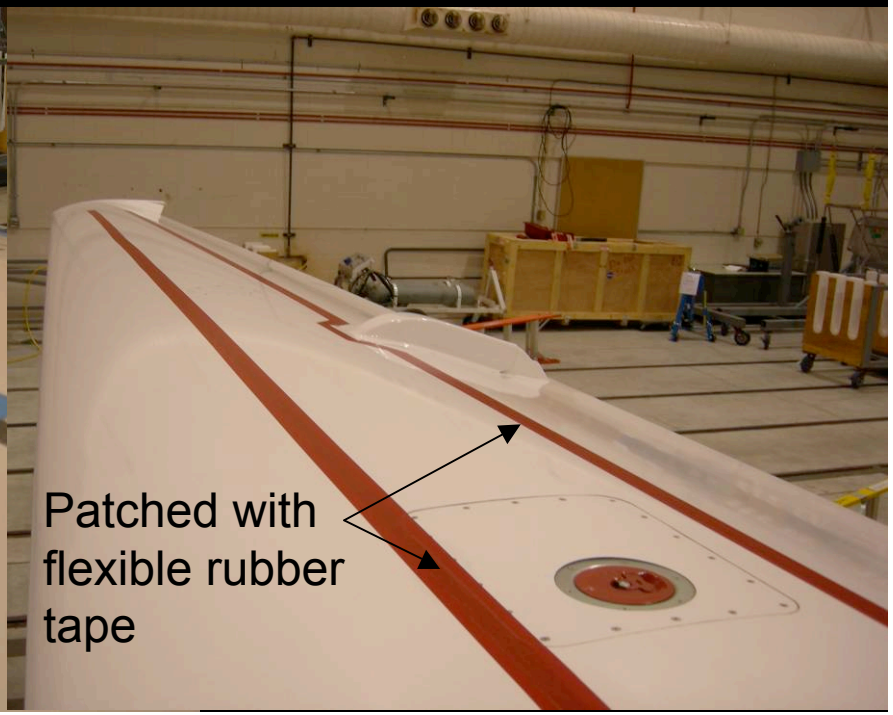
3rd Fire Mission 9/7/07
20 hours
3200 nmi

4th Fire Mission 9/27/07
10 hours
1800 nmi

California Emergency Wildfire Response

- Oct 20-21: High winds (>50 MPH) drive wildfires in 4 southern California counties
- Oct 22nd: Ikhana team began preparation for a possible fire mission
- Two impediments to launching a mission
  - Failed hard drive in the wildfire sensor
  - Ikhana wings being modified for fiber-optic wing sensor demonstration
    - Tiger team assembled to assess airworthiness





California Emergency Wildfire Response

Oct 22nd - Monday

- Ikhana Project team contacted by California Office of Emergency Services requesting imagery of Southern California wildfires
  - Kim Zagaris, Chief Fire and Rescue Branch
  - 500,000 people evacuated
  - More than 11 fires burning
- Planning telecons held with NASA teams and USFS
- FAA notified
- Range safety office began reviewing population centers around fire areas
- NASA Ames and USFS teams deploy to Southern California
- Wing repair completed

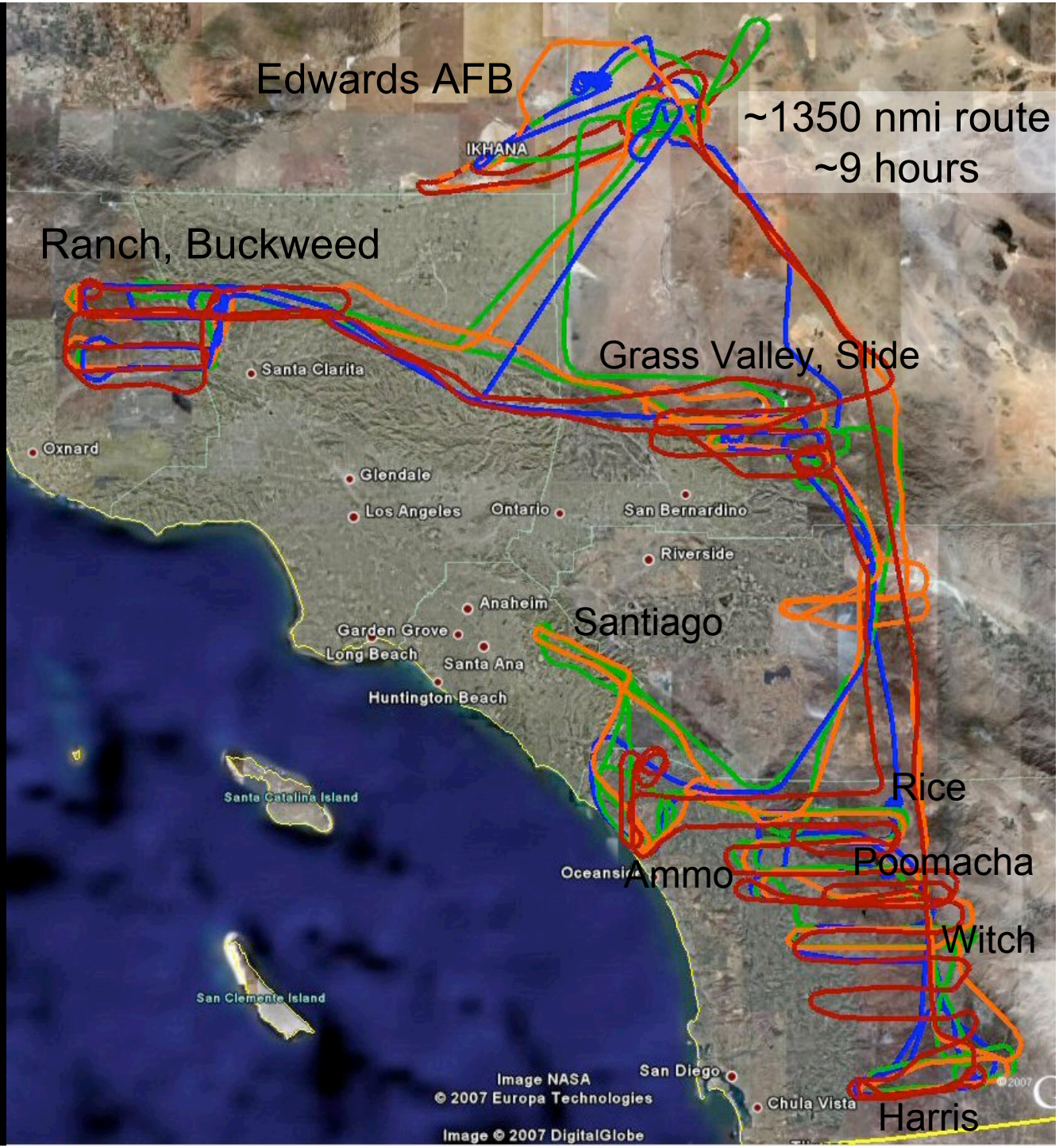
Oct 23rd - Tuesday

- Sensor hard drive repaired and verified
- FAA extended 75 nm COA limit to the south
  - Could not extend COA to within 10 nm of Mexican border (Harris fire)
- Mission plan submitted to FAA
- Tech Brief of mission plan delivered to NASA Dryden Management

Oct 24th - Wednesday

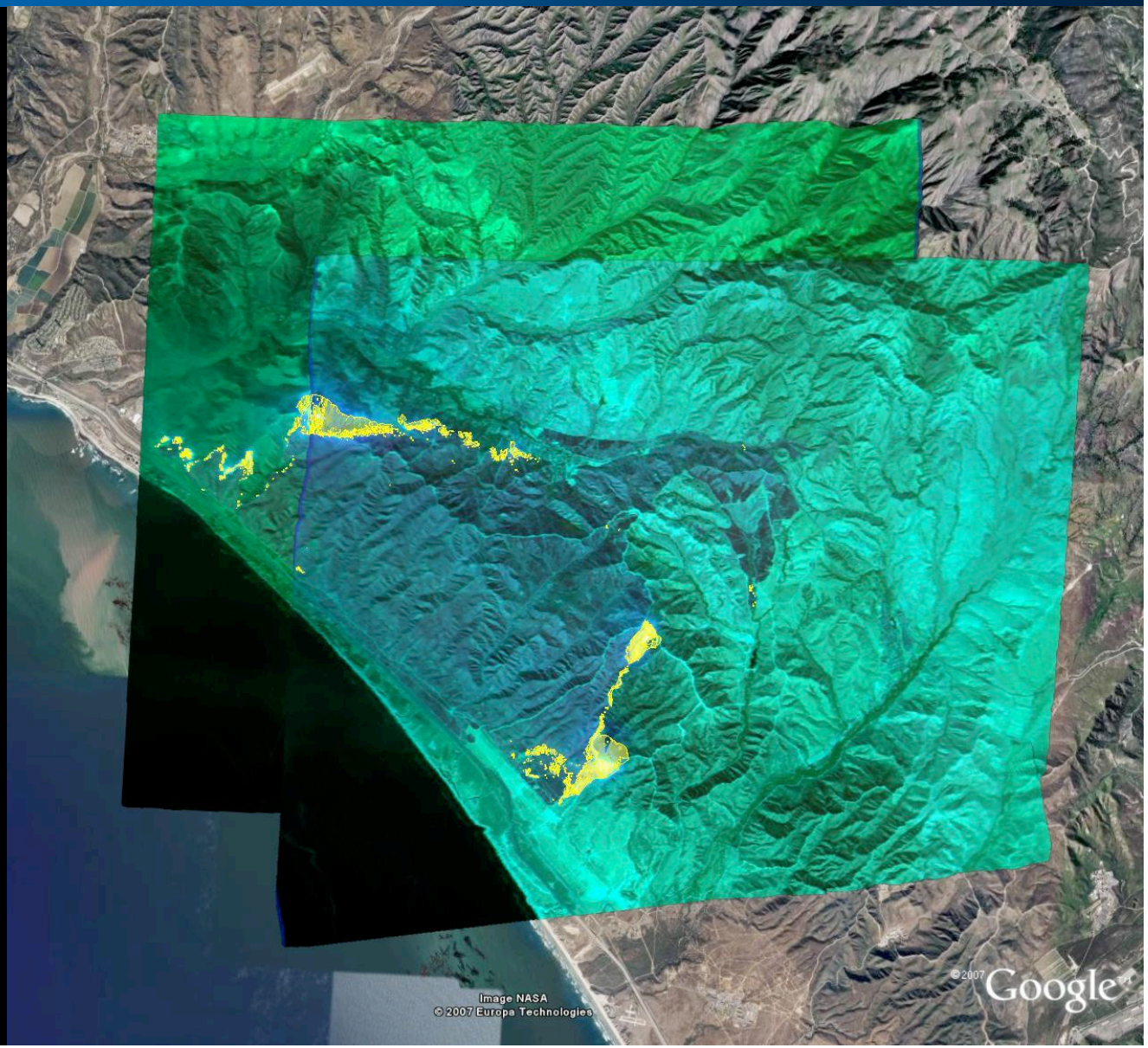
- Launched 1st emergency response mission @ 9am

SoCal Emergency Response Missions



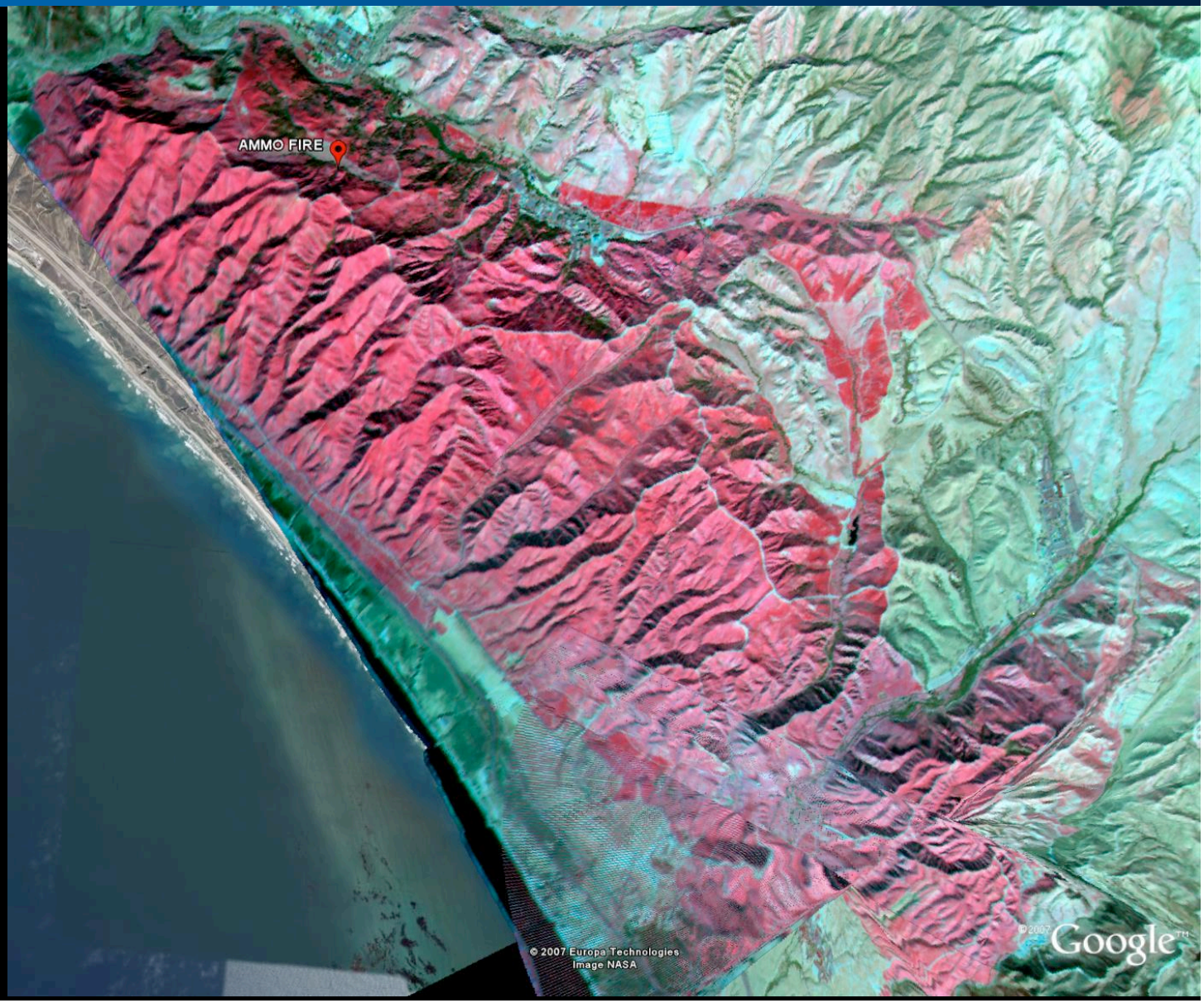
Ammo Fire, Oct 24th

Hot spots in yellow

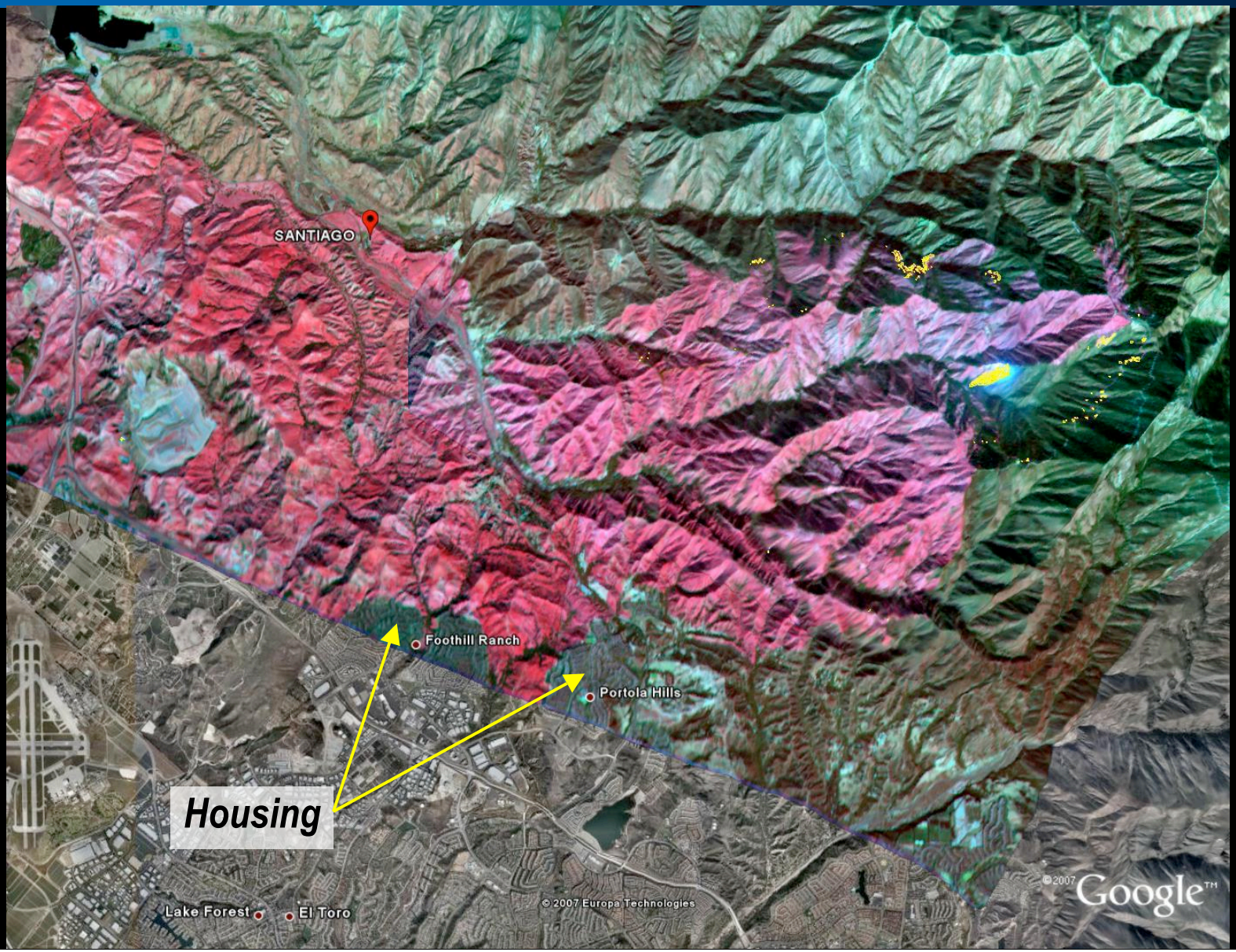


Ammo Burn Area, Oct 28th

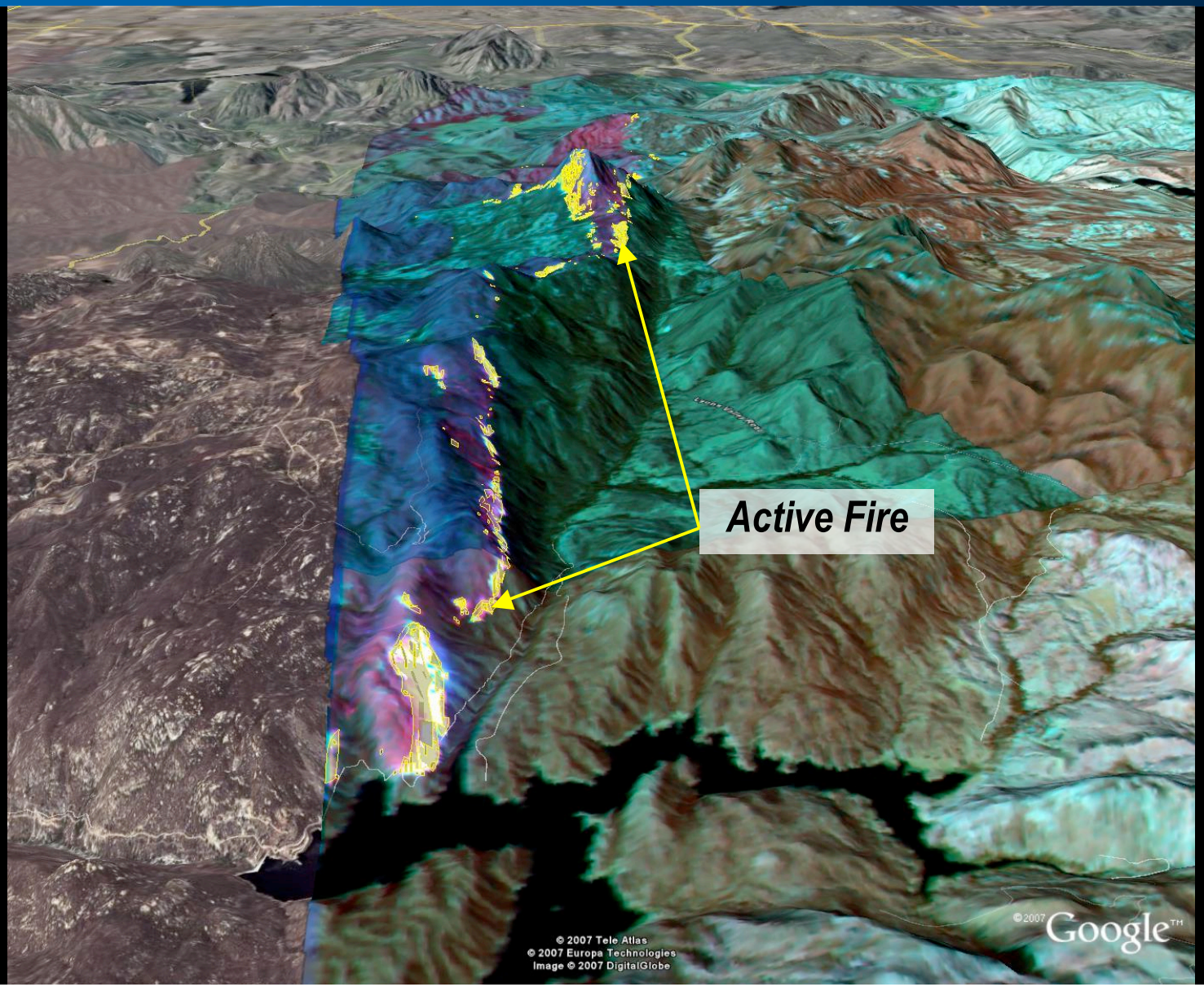
Sensor optimized for Burn Area Emergency Response (BAER) imagery



Santiago Fire, Oct 28th

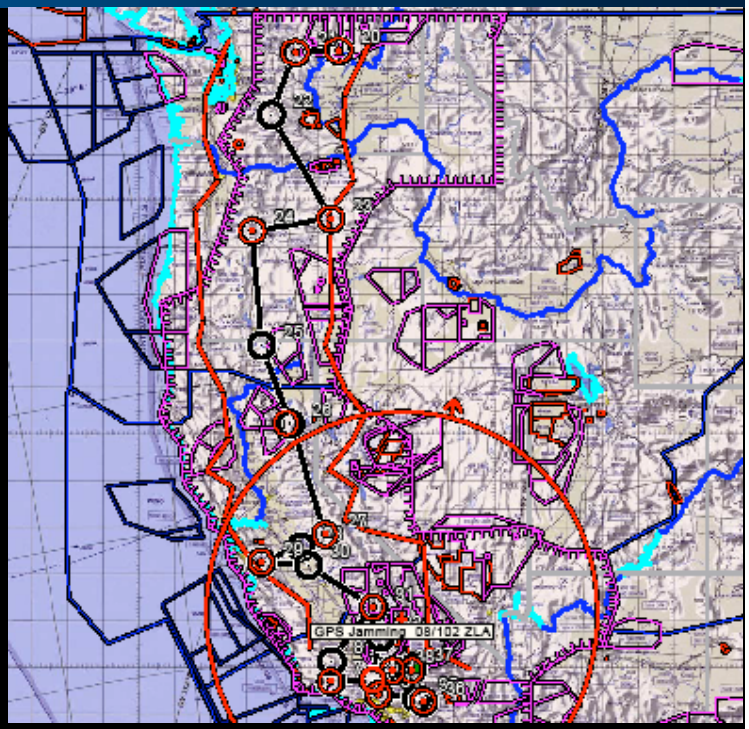


Harris Fire, Oct 27th



2007 WSFM Challenges

- GPS Testing – 250+ nm radius
  - Nellis Range & China Lake
  - Had to work around jamming during Demo flights
  - DOD worked around our ops during Emergency flights
- Command/Control frequency access
  - Competing with Gray Butte, Air Force, Navy Operations
- Emergency landing site permission
  - Must negotiate with each individual location
- Weather
  - Wind, Clouds, Icing, Thunderstorms
  - We had to deal with all 4
- Long missions
  - Significant challenges to execute a multi-shift operation and keep costs down
  - Crew rest requirements



Mission Results

- Four demonstration and four emergency fire imaging missions completed
- Thermal infrared imagery delivered in near real-time (5 to 15 minutes) to:
  - SoCal Emergency: FEMA, NIFC, NorthCom, California EOC
  - Demo Flights: NIFC, Individual Fire Incident Commands
- Imagery used for tactical and strategic decision making

- Air Traffic Control gave excellent support
  - Mission plans flown in reverse
  - Real time requests for revisits of active fires
  - Added new fire during mission
  - Moved fire loiter points as fires moved
  - Real-time reroute around thunderstorm activity
- Pre & Post flight telecons with FAA were held to review mission and discuss operational improvements
  - No issues with air traffic control during the 8 fire missions flown

Success of the Mission Depended on…

- NASA – Ames team, US Forest Service, NIFC, CalFire
  - Built the IR Sensor
  - Built the Collaborative Decision Environment (CDE)
  - Effectively used the information once it came off the aircraft
- General Atomics
- The FAA HQ UAPO (UAS) Office
  - Not possible without GREAT cooperation and communication
- FAA ATC Centers and Controllers
  - Los Angeles, Oakland, Seattle, Salt Lake, Albuquerque, Denver
- USAF
  - Gray Butte for Command/Control frequency flexibility
  - Nellis Range for GPS Testing flexibility
- DFRC Range Safety Office (RSO) - Population Keep-out Zones


Questions?
IKHANA
NASA
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